were simply due to the sunlight shining through and illuminating the particles in the crape ring for the inner condensations, and a similar effect of the Sun shining through the Cassini division and illuminating the particles in it would produce the outer condensations.

The fact that the inner and outer condensations were essentially of the same intensity would require that the particles should be as closely clustered in the Cassini division as they are in the crape ring.

With the assumption that particles do exist in the Cassini division, the above explanation of the condensations would be satisfactory.

In any attempt to connect the inner condensations with the crape ring, it may be important to state that these condensations have always appeared much brighter than the crape ring has ever appeared to me—even allowing for that ring being ordinarily seen between two bright regions, the inner bright ring and the ball of Saturn.

In conclusion, I am greatly indebted to Professor Frost for the extra time with the 40-inch to observe the phenomena of the disappearances and the reappearances of the ring of Saturn, and for the kind interest he has shown in the work.

Yerkes Observatory,
Williams Bay, Wis.:
1908 *January* 10.

A few Observations of the Planet Saturn and his Rings in the Years 1897–1904. By E. E. Barnard. (Plate 11.)

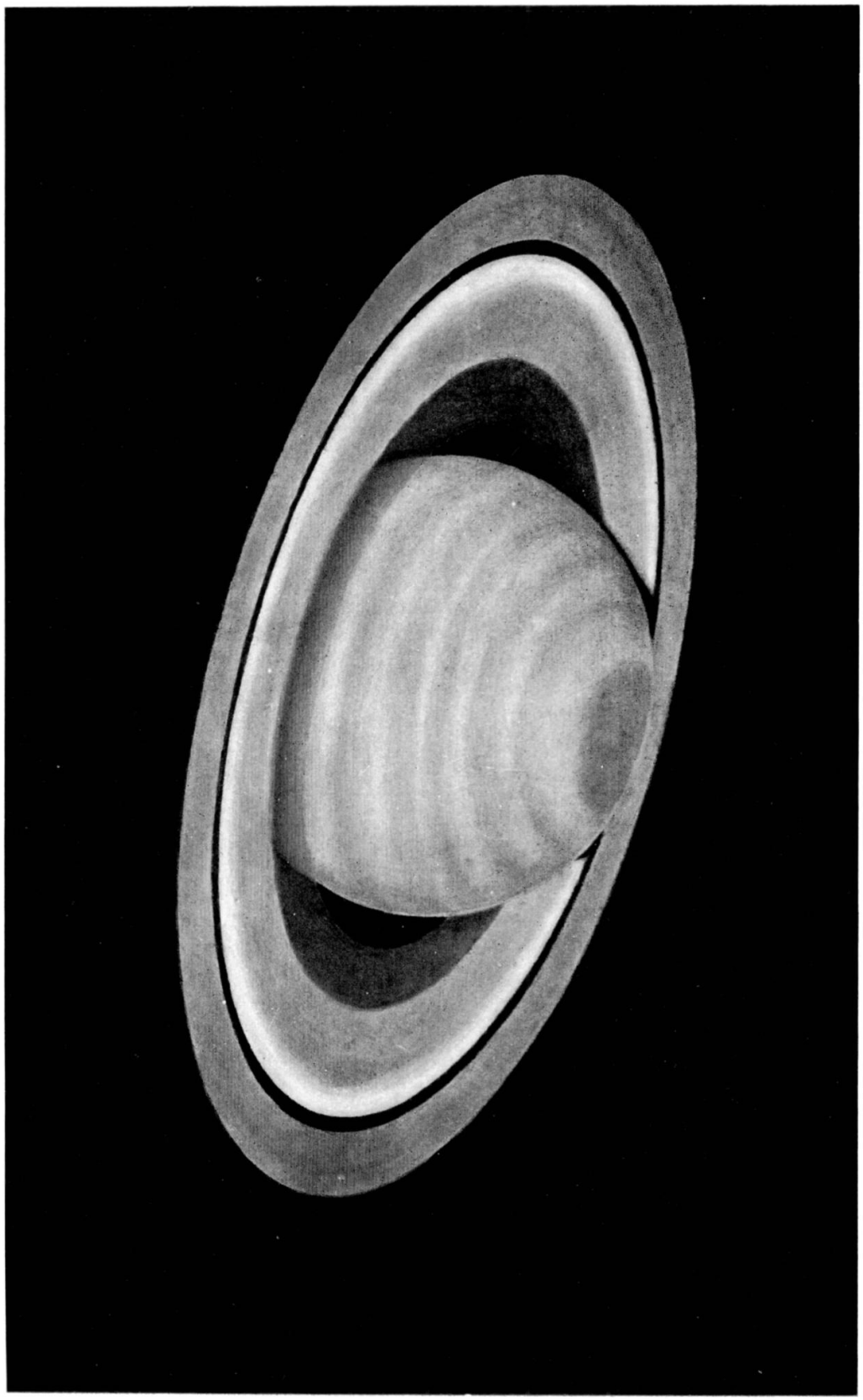
In connection with the papers on the disappearance of the ring of Saturn, I have thought it might be interesting to include in a separate short paper some other notes on the planet.

I have a number of observations of Saturn made here in the past ten years. Some of these are perhaps worthy of record, as they bear on the appearance of the planet with the large telescope when the rings were wide open, and I have collected a few of them for this paper.

1897 May 24. The north polar cap of Saturn was of a bluish dark colour—not well seen. It was bordered by a light belt.

1897 July 1. (With the 12-in. telescope.) The rings were opened so that their outer edges seemed to be exactly coincident with the polar limb of Saturn. It appeared perfectly so on this date, and also on June 29. The shadow of the ball on the rings seemed to be "squarey" where it struck the Cassini division. The polar cap was dark grey and not large. It was bordered by a light space, then a delicate dark narrow belt. There was no light equatorial zone.

I think this angular or "squarey" form of the shadow of the ball on the ring was simply caused by the shadow falling on the



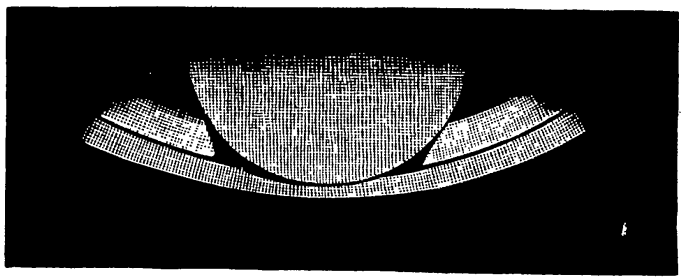
SATURN.

With the 40-inch refractor of the Yerkes Observatory, 1898 July 7, 9 h. 20 m.—E. E. Barnard.

Cassini division and producing thus a kind of "black drop" effect by the junction of the black shadow with the black space.

1898 February 26. The shadow of the ball on the rings was not a uniform curve, but of an angular outline, as shown in the

South.



Form of the shadow of the ball on the Ring of Saturn, 1898 February 26.

sketch. The north pole was dark—not black. The ball was clearly seen through the crape ring.

1898 March 6. The shadow of the ball on the rings preceding seemed "squarey." The north pole was dark.

1898 April 20. There was no definite dark polar cap such as was seen last year, but the polar regions were dark. The planet was beautifully seen through the crape ring. The shadow of the ball on the rings looked "squarey."

1898 July 7. The trace of the crape ring was hazy at both edges, or rather the inner edge of the bright ring was ill defined where it crossed the ball, but it was well defined on the sky between the ring and the ball. The crape ring was easily seen and well defined on the sky, but faint where it approached the ball. The two northern belts were more in contrast, or darker near the limbs of the planet. The inner bright ring was brightest toward the Cassini division, where the brightness was rather narrow. I could not see with certainty any division in the outer ring. There seemed to be a dusky shading where the Encke division is usually shown. The polar cap was darker than the darkest part of the ball.

The definition was superb. I have never seen the planet better, nor have I seen so much detail upon it before. The belts, as shown on the drawing (Plate 11), were seen with certainty. The ball was easily visible through the crape ring.

1899 April 7. $16\frac{1}{2}^{h}$. A heavy diffused belt at the equator. The north pole seemed dark. Seeing poor.

1899 April 25. The north pole was not very dark. The black, well-defined cap was not present. It was a little dusky at the pole.

1901 October 21. $17^{h}\ 50^{m}$. There was no polar cap. There seemed to be a luminous appearance near the north pole, at a point inside the following limb near the shadow; seeing fair, but planet very low.

1904 June 17. There was a heavy, diffused, broad dark belt north of the equator.

1904 July 2. The north belt was very heavy and diffused.

1904 July 4. The north belt was heavy and broad.

1904 July 11. The north polar region was of a light yellow colour.

1904 August 27. The north polar region was light-coloured.

1904 December 5. Light at the equator, with broad dusky region toward the north, but all the north region was lighter.

I have purposely withheld (for another paper) the observations of Saturn in 1903, at the time of the appearance of the white spot on the ball of the planet.

Unless otherwise stated, all the observations in these papers were made with the 40-inch telescope.

Yerkes Observatory,
Williams Bay, Wis.:
1908 *January.*

Photometric Measurements of Saturn, August to December 1907.

By J. M. Baldwin, M.A., 1851 Exhibition Scholar (Melbourne).

(*Communicated by Sir David Gill.*)

During the recent opposition of Saturn, at the suggestion of Professor Müller, I undertook a series of photometric measures of that planet. This opposition has been of particular interest, for, owing to the small elevation of the Earth above the plane of the ring, the reduction to "ring invisible" is subject to very slight uncertainty, and so the variation in the brightness of the spheroid itself with phase angle can be obtained.

Seeliger* has theoretically arrived at an expression for the magnitude of Saturn, in which the magnitude depends on two quantities, the first of which, expressing the light received from the ring, shows a marked variation with phase, while the second, expressing the light from the spheroid, is almost independent of phase. Müller,† on the other hand, has arrived at empirical formulæ for the magnitude, in which the variation in magnitude is proportional to the change in phase. In discussing his observations and those of Zöllner, he remarks (*l.c.*, p. 343), "es scheint also, als ob auch bei gänzlich verschwundenem Ring ein Einfluss der Phase sich geltend mache"; and Pannekoek‡ has further emphasised this point, showing that the observed change of brightness with phase when the elevation of the Earth above

* H. Seeliger, *Abhandl. der Bayer. Akad. der Wissensch.*, Bd. 16, 403, 1888.

† G. Müller, *Publ. des Astrophys. Observ. zu Potsdam* 8, 339 u. 341, 1893.

‡ Ant. Pannekoek, *Ast. Nach.* 4006, Bd. 167, 363, 1905.